High Performance School Buildings Workshop

March 23, 2011

How to Get a High Performance School

Farristown Middle, Madison County

Crossroads Elementary, Bullitt County

John A. Newman, P.E.

ClotfelterSAMOKAR

Introduction

- Decisions made now affect other's future.
  - When I started – Client was "Owner". Only person I had to satisfy.
  - Later, Clarence Frasier said it was "The Building".
  - Now the Client is the "Earth!"

- Ultimately, we must be more responsible and wise in our decisions.

ClotfelterSAMOKAR

Farristown Middle School, Madison County

ClotfelterSAMOKAR

Farristown Middle School, Madison County

Two schools - Same county and footprint. We are able to modify and see results!

Caudill Middle School

- Not submitted for “Designed as Energy Star” but,
- Applied for Energy Star label – 40.8 kBtu/SF with a rating of 85.
- Bid Date May 6, 2008
- HVAC $ 23.83/SF

Farristown Middle School

- Awarded Designed in Accordance with Energy Star with rating of 90
- Occupancy Sensor Controlled Outside Air – VFD MAU’s
- Enhanced Building Envelope
- Student Interaction Energy Monitor
- Still Under construction
- Bid Date May 11, 2010
- HVAC $23.07/SF

ClotfelterSAMOKAR

What was impact on project costs?

- Cost increases from Caudill to Farristown
  - Enhanced Energy Monitoring + OA Dampers on HP's/VFD MAU's
    - Controls increased 3% for HVAC and 0.25% impact on the total project costs - minimal
  - MAU Equipment costs
    - Equipment costs increased 3% HVAC costs and 0.27% impact on the total project costs – for a total of 0.57% increase on the total project. Again Minimal
- But HVAC costs for both projects stayed about the same! So these costs were really absorbed in the overall scheme of things.
- In summary, small changes like these have little impact on overall project costs.

ClotfelterSAMOKAR

Farristown Middle School, Madison County

Overview

- Energy Monitoring in Separate wings to promote student awareness
- Low Friction Piping Systems
- Variable Speed Pumping and outside air units
- Occupancy Sensors controlling HVAC
- Geothermal Wellfield Economizer System
- Enhanced Building Thermal Envelope

ClotfelterSAMOKAR

Farristown Middle School, Madison County

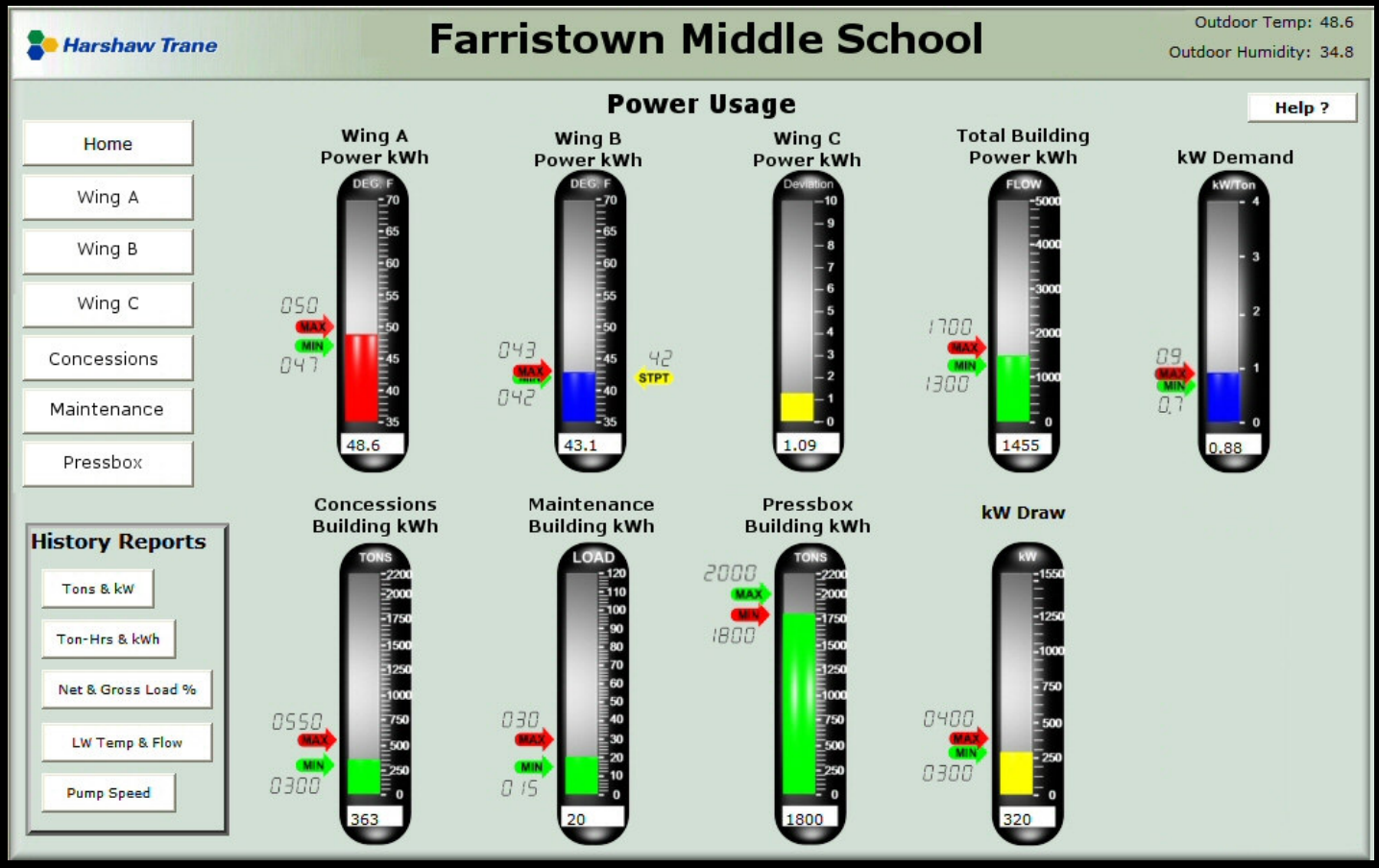
Energy monitoring in separate wings to promote student awareness and give valuable feedback to design teams

- In addition to wings - not expensive to add energy usage meters throughout the school for Gym, Kitchen, exterior lighting…. This information gives the user/engineers valuable information on building performance
- Enables continuous commissioning to identify systems that get “out-of-whack”.
- Use student competition and interactive monitors to create a culture among students and staff that drives behavior and responsible energy use and saves $ and reduces greenhouse emission ultimately.

ClotfelterSAMOKAR

Farristown Middle School, Madison County

Energy monitoring in separate wings to promote student awareness and give valuable feedback to design teams



ClotfelterSAMOKAR

Farristown Middle School, Madison County

Low Friction Piping Systems

- Use of HDPE fused piping interior of the building. We can be liberal in over sizing to 2'/100' max pressure drops, to reduce pump head.
- Eliminate all unnecessary pressure eating devices such as hose kits in piping connections to heat pumps. Some schools we have eliminated circuit setters and flow regulating valves and just balanced on return ball valve using memory stops.
- Goal is to keep Pump Heads less than 60 feet of head, and pump horsepower below 15 HP.

Photo of clear pipe for inspections – All Pipe HDPE

ClotfelterSAMOKAR

Farristown Middle School, Madison County

Impact of keeping pressure drops to a minimum

- If you save one pump brake horsepower (bhp):
  - 6,535 kwh/Yr at $ 0.07/kwh = $ 457/yr!
  - Circuit Setter or flow regulating valve any heat exchanger can generate up to 10 feet of head = $ 1,005/yr
  - Constant speed pumps have triple duty valves – variable speed does not. Two triple duty valves (primary/secondary) set at 33% closed on a 15 horsepower pumps cost $ 1,552/yr. You can replace Pump starters in existing schools to VFD's and get a quick payback.

ClotfelterSAMOKAR

Lighting Controls – Quick Note

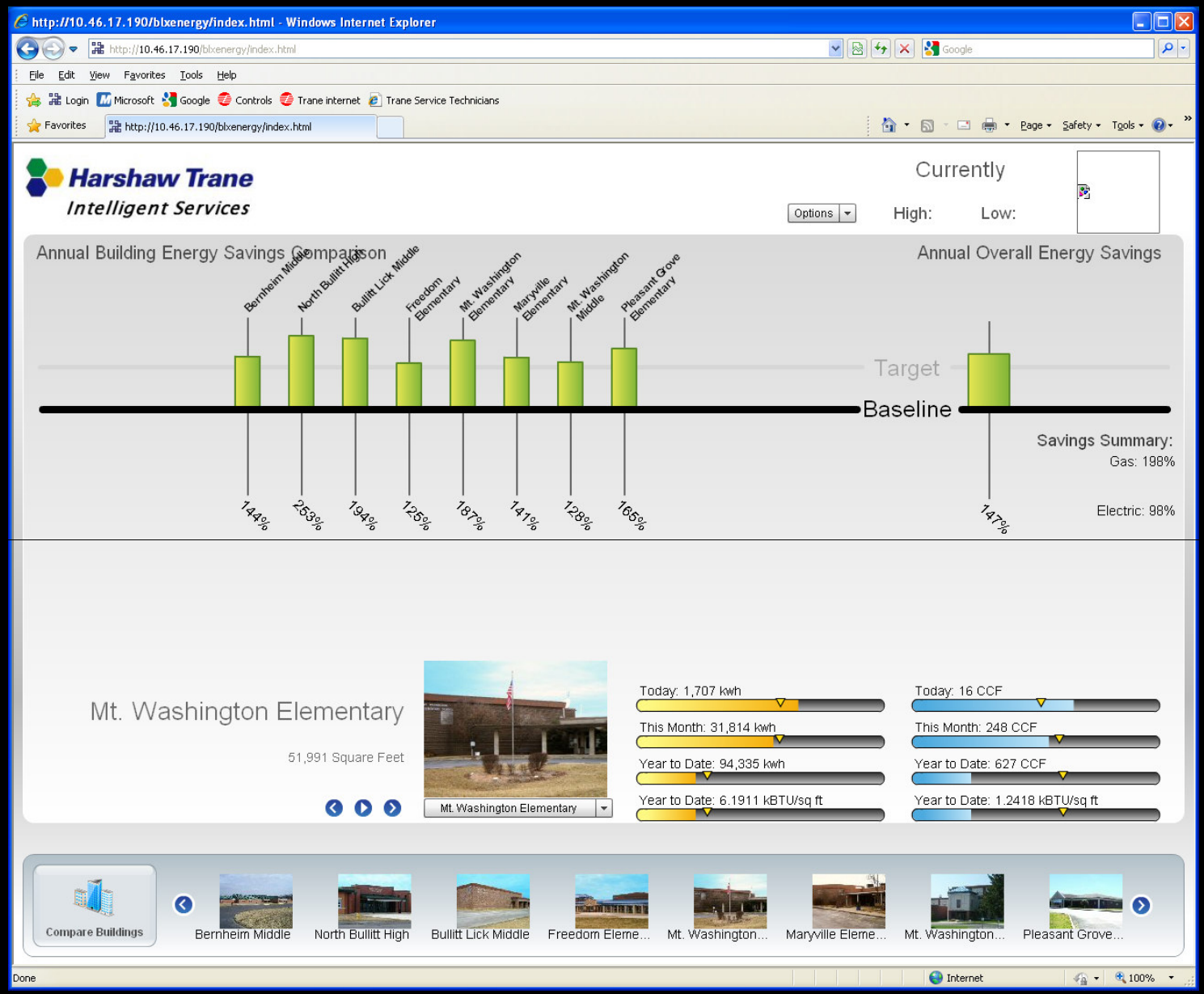
Other Than Occupancy Sensors any more complicated system does not have serious impact

- Consider:
  - We are now designing schools with 0.85 Watts/SF in Classrooms! When I started designing we didn't keep score but is was about 1.6 to 1.8 Watts/SF.
  - 176 School Days round up to 210 for maintenance and in-service. At 9 hours per day and $ 0.07 per KWH total cost for lighting a classroom is $81/yr.
  - Some lighting dimming systems can run at $500 per classroom this results in a payback in 31 Years.
  - Therefore go after bigger fish! OUTSIDE AIR and COOKING EQUIPMENT!

ClotfelterSAMOKAR

Crossroads Elementary, Bullitt County

ClotfelterSAMOKAR



ClotfelterSAMOKAR

Crossroads Elementary, Bullitt County

Two schools – Again same county same footprint! We were able to modify and are now seeing the results!

Roby Elementary

- Awarded Designed in Accordance with Energy Star
- Earned Energy Star Label in 2010.
- Bid Date January 30, 2008
- HVAC $ 27.33/SF

Crossroads Elementary

- Awarded Designed in accordance with Energy Star
- Kitchen exhaust energy recovery
- Occupancy Sensor Controlled Outside Air – VFD/MAU's
- Wellfield economizer in MAU
- Enhanced Building Envelope
- First five months – Energy usage is 5% less than Roby Elementary
- Bid Date May 19, 2009
- HVAC $ 23.78/SF

ClotfelterSAMOKAR

Crossroads Elementary, Bullitt County

Kitchen Equipment and Water Usage

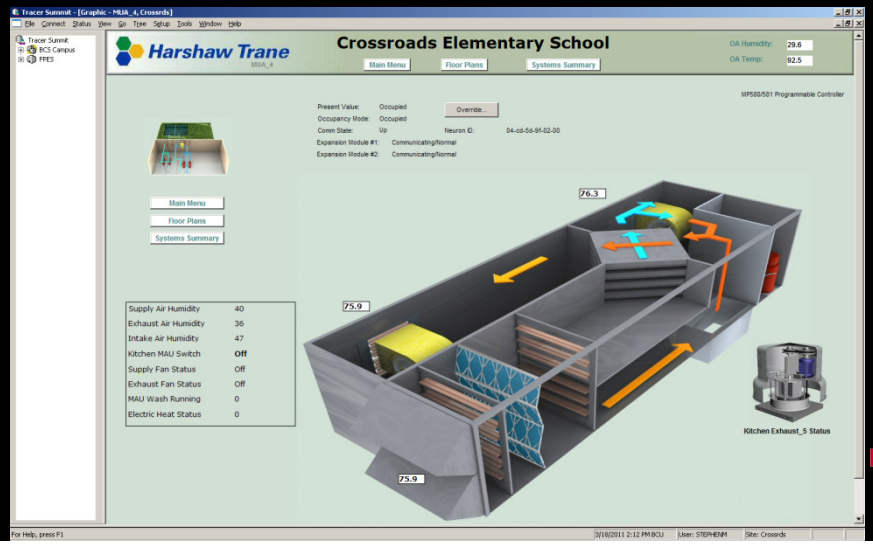
- As we reduce overall HVAC system energy usage, Kitchen equipment control has become a larger piece of the pie!
- Energy Recovery of Range Hood Exhaust Air
- Dishwashing – use low water consumption dishwashers = less heat and water usage.
- Kitchen equipment usage numbers:
  - Combi-oven usage 5.0 hours five days per week
  - Small Kettle usage 3.0 hours once per week
  - Tilting Skillet usage 2.0 hours twice per week
  - Dishwashing 6.0 hours five days per week – 50% diversity

ClotfelterSAMOKAR

Crossroads Elementary, Bullitt County

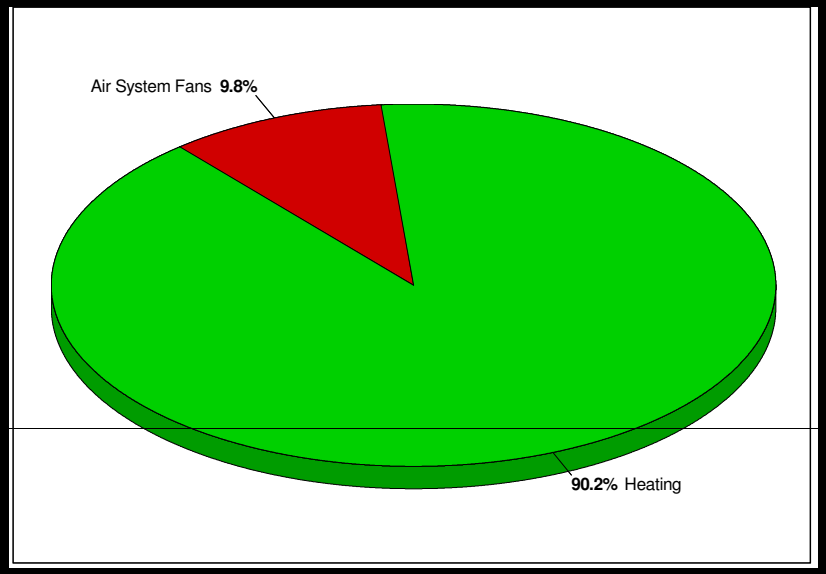
Kitchen Range Hood Exhaust Energy Recovery

- Recent trend is to lower required CFM at range hoods – VFD or High Efficient Hoods – Good!
- Some try to eliminate Makeup Air at Hoods altogether and use the building's outside air from other sources. We are concerned, that doing so, you do not get the benefit of extracting building heat through a heat exchanger. Thus, dedicated makeup air units with heat recovery will capture this heat.
- We are doing this for schools with Type II (condensate) hoods only. Wash-down cycle once per week. For one year operation very minor grease buildup.



ClotfelterSAMOKAR

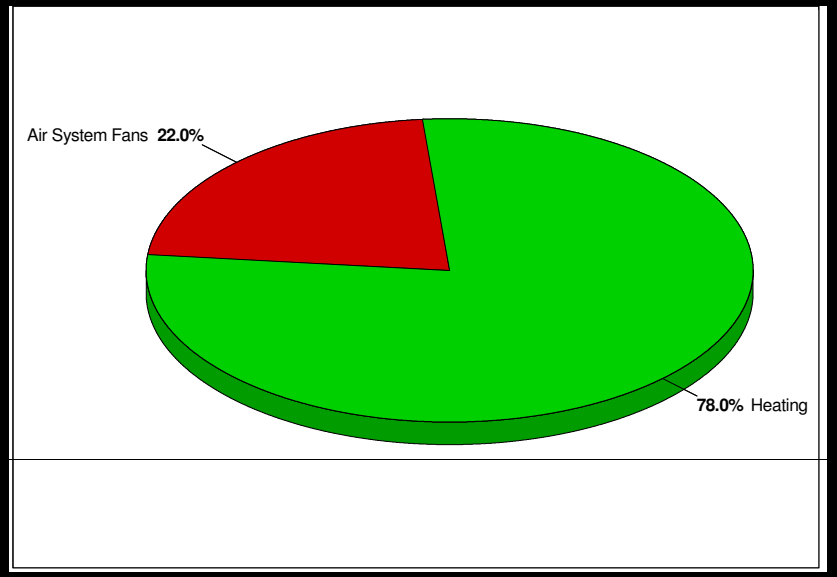
Kitchen Exhaust - Not Recovered



Component	Annual Cost ($)	($/ft²)	Percent of Total (%)
Air System Fans	489	2.445	9.8
Cooling	0	0.000	0.0
Heating	4,515	22.575	90.2
Pumps	0	0.000	0.0
Cooling Tower Fans	0	0.000	0.0
HVAC Sub-Total	**5,004**	**25.020**	**100.0**
Lights	0	0.000	0.0
Electric Equipment	0	0.000	0.0
Misc. Electric	0	0.000	0.0
Misc. Fuel Use	0	0.000	0.0
Non-HVAC Sub-Total	**0**	**0.000**	**0.0**
Grand Total	**5,004**	**25.020**	**100.0**

ClotfelterSAMOKAR

Kitchen Exhaust - 50% Energy Recovery



$ 5,004 - $ 2,630 = $ 2,374/Year Savings!

Component	Annual Cost ($)	($/ft²)	Percent of Total (%)
Air System Fans	577	2.886	22.0
Cooling	0	0.000	0.0
Heating	2,052	10.261	78.0
Pumps	0	0.000	0.0
Cooling Tower Fans	0	0.000	0.0
HVAC Sub-Total	**2,630**	**13.148**	**100.0**
Lights	0	0.000	0.0
Electric Equipment	0	0.000	0.0
Misc. Electric	0	0.000	0.0
Misc. Fuel Use	0	0.000	0.0
Non-HVAC Sub-Total	**0**	**0.000**	**0.0**
Grand Total	**2,630**	**13.148**	**100.0**

ClotfelterSAMOKAR

Crossroads Elementary, Bullitt County

Variable Air Volume Makeup Air Units

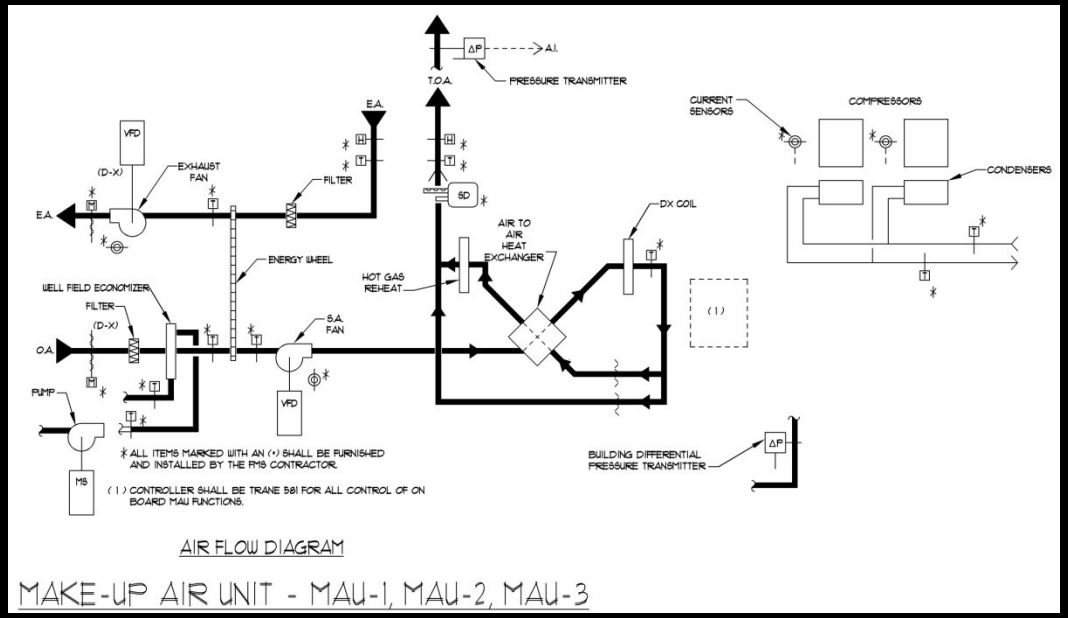
- Makeup Air Units use Variable Frequency Drives on Supply and Exhaust air fans.
- Occupancy sensors that control lighting also control motorized dampers on Heat Pump Tempered Outside Air connections.
- Only outside air needed for a space is used.
- Drawback – same amount of outside air for 1 or 25 occupants. This can be further controlled using a variable volume box and CO_2 sensor for demand controlled ventilation.

ClotfelterSAMOKAR

Crossroads Elementary, Bullitt County

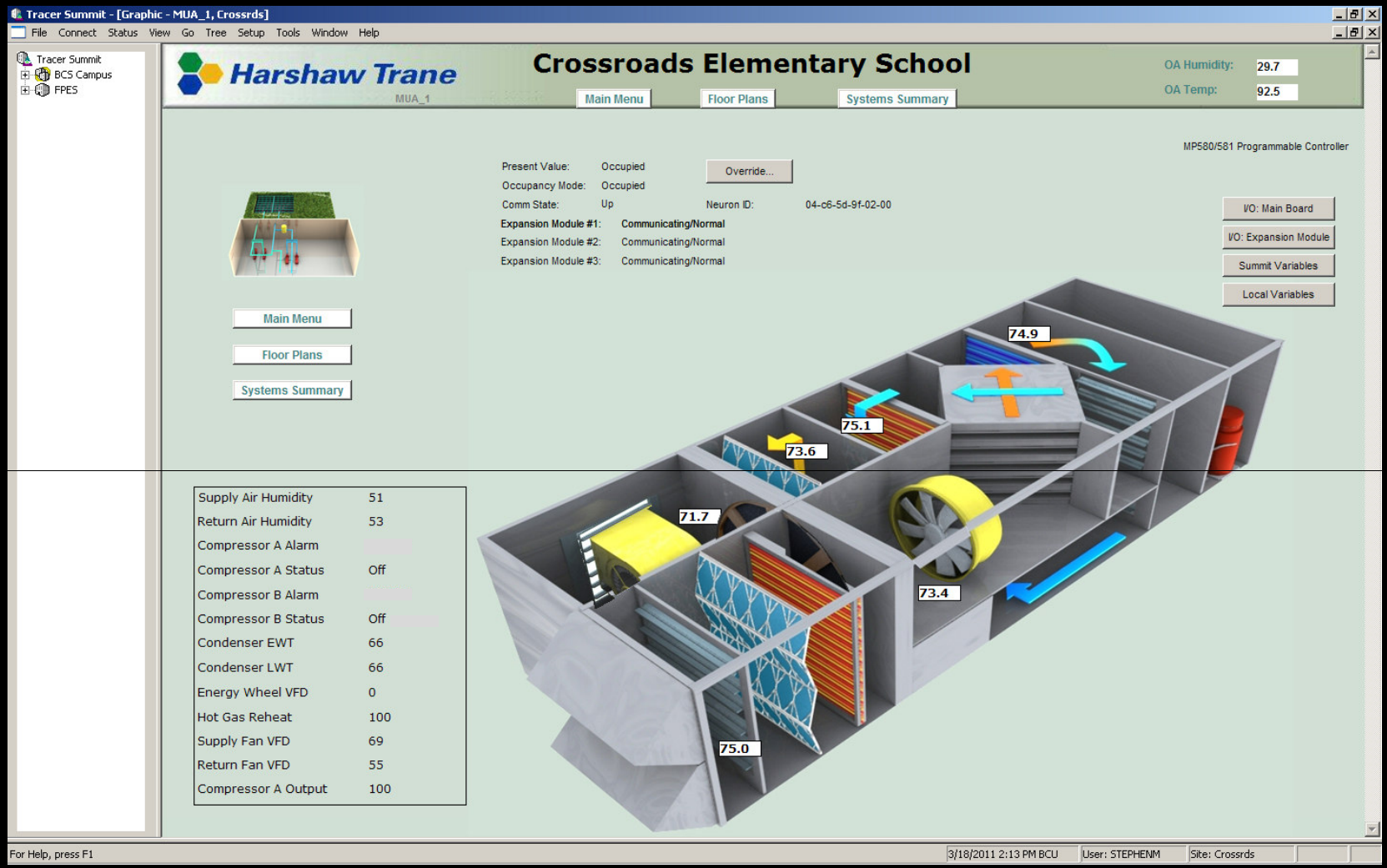
Makeup Air Units With Well Field Economizer

- Install a coil directly in the incoming outside air of the makeup air unit. Coil is in the geothermal return piping back to the wellfield.
- Extracts heat during the winter months to bring wellfield under control for the summer months. And helps pre-heat entering air to the MAU – but not the reason for the coil.



At 25 degrees outside for one unit we were extracting 30 tons of heat from the well field.

ClotfelterSAMOKAR



ClotfelterSAMOKAR

Crossroads Elementary, Bullitt County
Farristown Middle, Madison County

Enhanced Building Envelope Insulation

Roby Elementary

- Roof Batt Insulation R-22.4
- Walls Rigid Insulation R-8.1
- Windows – Not Low e

Crossroads Elementary

- Roof R-30 Board
- Walls Masonry Foam R-9.6
- Walls Exterior Stud R-30
- Windows – sc 0.32 South and ~~West~~
- Windows - sc 0.53 North and East

Caudill Middle

- Roof Batt Insulation R-19
- Walls Rigid Insulation R-7.5
- Windows – sc 0.34

Farristown Middle

- Project had an alternate to go from Rigid Insulation in walls to Foam. Cost to go to R-7.5 to Foam R-9.6 - $ 50,000 Savings!

ClotfelterSAMOKAR

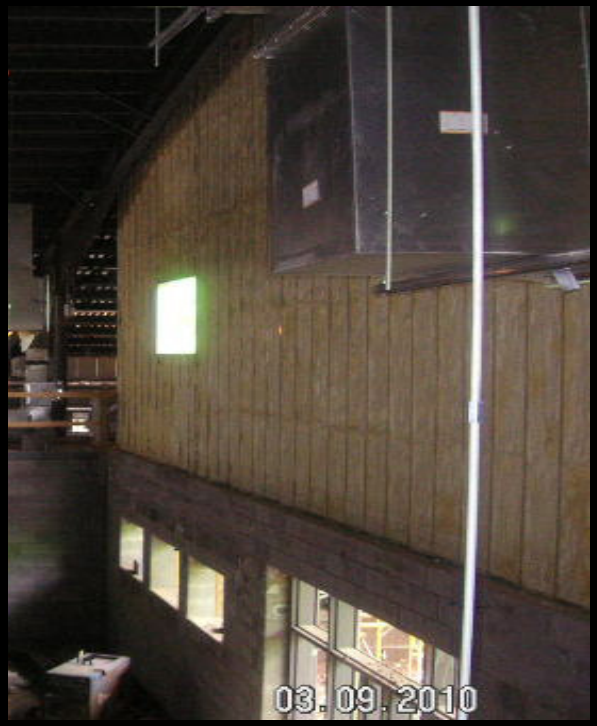
Crossroads Elementary, Bullitt County

ClotfelterSAMOKAR

Crossroads Elementary, Bullitt County

Enhanced Building Envelope Insulation Building resembles a Thermos Bottle!

Foam Insulation = minimum leaks



R-30 Exterior Stud Wall

ClotfelterSAMOKAR

Simulating/Modeling Buildings for Energy Star

- Schedules
  - Need separate schedules for gym, cafeteria, water heating/dishwashing, kitchen range hood equipment, office areas……The more, the better!
  - Makeup air units - very important to schedule each individually.
  - Biggest impact on controlling energy is kitchen equipment and makeup air units.
  - Ask questions – get with school personnel to obtain actual hours of use.
- Use Real Life Equipment Ratings
  - Look at computers the school is using.
  - Use actual nameplate data for cooking equipment

ClotfelterSAMOKAR

Future

1. If Earth is Client now…. we need to make sure we do not pollute our extra-stellar neighbors. So we need to filter out i-Carly and Suite Life of Zack and Cody episodes!

- Centralized geothermal combined systems using VAV boxes with multistack technology for reheat.
- Target non HVAC items – envelope, occupant usage and awareness/interaction, water heating.

ClotfelterSAMOKAR

Thank you!

ClotfelterSAMOKAR